Vacuum Technology
Room 101D - Session VT-WeM

Vacuum Technology – History and Innovation (8:20-10:00 am)/Transfer and Manipulation (11:00 am-12:20 pm)
Moderator: Jay Hendricks, National Institute of Standards and Technology

8:20am **VT-WeM2 A New Approach to Vacuum Technology Education at a Distance*, Del Smith*,** *N. Louwagie,* Normandale Community College

Education and training for technicians who work in the vacuum and vacuum coating industries is becoming more critical as the complexity of the equipment and processes increases. In addition, many of those currently working as technicians are approaching retirement age, with no obvious source for the large number of replacement personnel that will be needed. Many technicians will benefit from a formal educational program giving them grounding in the basic sciences and developing their soft skill set. Several local companies utilizing vacuum and coating technologies partnered with Normandale Community College in 1998 to develop a formal educational program to train technicians in the basic concepts of vacuum and thin film technology. Recently, the need for the expansion of this program to geographic areas that are currently underserved and cannot support a college program in these specialties became apparent. Normandale Community College in Bloomington, MN, is in its second year of a three year project, funded by the National Science Foundation, Division of Undergraduate Education, Advanced Technological Education. The focus of this project is to develop the vacuum technology curriculum, processes and equipment needed to train technicians at locations remote from the primary instructor. This paper presents the current status of this project, with details about curriculum development, remote classroom technology and the development and use of advanced vacuum training hardware systems for use at the remote learning site that include features not previously available.

8:40am **VT-WeM3 It's All Because of the Vacuum...*, H. Frederick Dylla,*** American Institute of Physics **INVITED**

A number of key scientific demonstrations from the 18th century to the present were enabled by the essential task of obtaining a low enough level of vacuum. This talk explores a number of well-known events in the history of science and technology that depended on achieving a remarkable level of high vacuum for the era contemporary to the demonstration. We start with Franklin's lyceum experiments where he applied static voltages across glass cylinders where pressures were lowered below ambient conditions with crude air pumps. This work presaged subsequent work on gas discharges and modern accelerator cavities. A century later, J. J. Thomson was the first to make an electron beam by lowering vacuum levels sufficiently to prevent ionized residual gas ions from shielding the negative particle beam. Fast-forward to the early 1960's where G.K. O'Neill invented the now standard configuration for contemporary particle physics experiments- the high intensity storage ring. This configuration demanded and achieved true ultrahigh vacuum levels on an industrial scale. The story concludes with this year's remarkable detection of gravity waves using LIGO - the kilometer-scale laser interferometers that required extreme high vacuum levels for all residual gas components.

9:20am **VT-WeM5 The Next Generation Quantum-based Metrology for Miniaturized Sensors and Standards*, Gregory F. Strouse,*** National Institute of Standards and Technology **INVITED**

Development of innovative sensors and standards that—through improvements in cost, size, speed, and durability—will enable new manufacturing processes, tools and products of tomorrow. The NIST vision is that these innovations will improve the dissemination of standards to the point where routine exchange of artifacts for measurement quality assurance is no longer needed. Quantum and photonic based rugged small-scale vacuum sensors open new horizons in measurement science and represent a paradigm shift in how metrology is done. Networks of small and precise sensors embedded within structures and composite materials could improve their performance and reliability. These sensors draw upon a range of technologies not previously exploited for these applications, such as nanofabrication, photonics, and atomic physics. Photonic and quantum-based vacuum sensors will allow both the absolute sensing of vacuum and the realization of the SI at the user site and will allow the user to calibrate other sensors or directly measure process vacuum levels for critical applications. Several related research programs at NIST are geared towards realizing the vision of small or chip sized absolute sensors for practical applications. NIST is building a sensor program, with the goal to establish a set of chip-scale tools that enable real-world use. An example is the chip-scale cold-atom technology requires maintaining UHV conditions throughout the operating lifetime of the device, posing practical technical challenges to the vacuum engineering. Our program to replace primary mercury manometers with photonic-based primary standard relies on lasers and Fabry–Pérot optical cavities that are stable from several atmospheres of pressure down to high-vacuum. These cavities will be field-deployable absolute sensors requiring no calibration. Other quantum and photonic based sensors include dynamic pressure measurements and thermometry. These programs will be discussed in terms of the larger programmatic view of how quantum-based, chip scale technologies will disrupt vacuum technology, primary standards, and pressure, vacuum and temperature measurement.

11:00am **VT-WeM10 Vacuum Transport for Realization and Dissemination of the Redefined Kilogram at NIST*, Eric Benck*,** *E. Mulhern,* NIST **INVITED**

In 2018 the unit of the kilogram will be redefined. Instead of being based on the physical artifact known as the International Prototype Kilogram (IPK), the kilogram will be defined by fixing the value of a fundamental physical constant, Plancks constant. It will now be realized using watt balance or x-ray crystal density (Avogadro) experiments. This will enable any research group throughout the world to realize the unit of mass if they have sufficient technical expertise and equipment. Both of these experimental methods are optimally designed to operate in vacuum. As a result, mass metrology must now deal with the issues of maintaining, manipulating and moving masses under vacuum.

At the National Institute of Standards (NIST), at least five different experimental systems operating in vacuum will be used for the realization and dissemination of the kilogram. First, the kilogram will be realized using the NIST-4 watt balance. Second, NIST is developing a unique apparatus called the magnetic suspension mass comparator (MSMC) to transfer the unit of mass in vacuum to a mass in air. Third, a commercial vacuum comparator will be used to directly compare different masses in vacuum and for sorption studies. Fourth, a new plasma cleaning station is being developed to use a downstream hydrogen plasma source to clean a mass. And finally, there will be a vacuum mass storage facility where multiple calibrated masses can be kept for later mass comparisons.

In order to transport a mass under vacuum between the different apparatus, a custom built mass transport vehicle (MTV) has been constructed. It is essentially a mobile vacuum chamber made out of a 4 way cross and gate valve. It has a wide range pressure gauge and a battery powered getter pump. The vacuum chamber is supported by an aluminum frame mounted on castors. The MTV can maintain a vacuum below $1.3x10^{-3}$ Pa for 30 minutes without pumping which is sufficient time to transport a mass between the different rooms housing the experimental apparatuses. The MTV can be attached to a load lock on each apparatus which can extract the mass and transfer it inside while maintaining the mass in vacuum. The complete transfer process of a mass from one machine to another with the MTV takes on the order of an hour. Most of this time is due to the evacuation time of the load lock after the MTV has been attached.

11:40am **VT-WeM12 Handling, Transfer ,Storage, and Shipping of Commercial Thin Film Hydride Disk Target Samples*, James Provo,*** J. L. Provo, Consulting

Handling, Transfer, Storage, and Shipping of Commercial Thin Film Hydride

Disk Target Samples

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Thin film hydride targets are important for many applications including,

accelerator research, various neutron devices, contraband detection, etc.

They are very sensitive to air-oxidation and easily contaminated by improper

handling . Air-exposure, which oxidizes Group IIIB, IVB, and rare earth film

materials, affects their operating properties. This paper will discuss the

development of handling techniques, and special transfer and shipping

containers for hydride target samples from post processing to transfer and

shipment to a customer. Studies were performed to determine the best physical handling devices, procedures for reducing particulate contamination, and for reducing air-exposure and moisture from samples before actual use. Initially, as an example, samples in an air-exposure hydriding system, were backfilled with an inert gas just before opening into an environmentally controlled clean room, quickly moved to an inert gas glove box, and then placed in special vacuum transfer or shipping containers, as quickly as possible, and then pumped down to a vacuum of ~ 1 x 10^{-7} Torr(1.33 x 10^{-5} Pa) or less. For optimum handling conditions, a system was developed with the major components being a hydride loading system in a double-sided stainless steel glove box contained in an environmentally controlled room. This glove box contained a loader vacuum chamber, a video microscope, a HEPA filter/ fan module and a hydriding gas manifold. The glove box had an inert Ar or N_2 atmosphere, achieved by circulating the gas through a commercially made purifier which striped oxygen and water vapor. The glove box atmosphere was monitored by an oxygen monitor, and a water vapor analyzer. When loaded samples are removed from the chamber of such a system, samples are automatically in a pristine environment,with very low particulate contamination, and a minimum amount of water vapor.

On the other side of the glove box, samples are placed into transfer and/or shipping containers, which are then pumped down to high vacuum conditions for shipment. Examples of sample handling clips, and sample containers are given.

Results have shown, that by using such methods and techniques, hydride target disk samples can be successfully processed, handled, transferred and shipped in a condition very close to that as processed out of a loader.

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